

FMR investigations of half-metallic ferromagnets

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Abstract

Thin films of various half-metallic ferromagnets, such as chromium dioxide (CrO₂) and Heusler alloys (Co₂Cr_{0.6}Fe_{0.4}Al, Co₂MnSi) have been investigated by ferromagnetic resonance (FMR) technique. It is demonstrated that FMR is a very efficient method to study the nanoscale magnetic properties, in particular to probe the magnetic anisotropy and magnetic inhomogeneities of ferromagnetic thin films. Epitaxial CrO₂ thin films of various thicknesses (25-535 nm) have been deposited on TiO₂(100) substrates by chemical vapor deposition process. It is shown that the magnetic behavior of the CrO₂ films results from a competition between the magnetocrystalline and strain anisotropies. For the ultrathin CrO₂ film (25 nm) the magnetic easy axis switches from the c-direction to the b-direction of the rutile structure. Thin-film Co₂Cr_{0.6}Fe_{0.4}Al samples (25 nm or 100 nm) have been grown by DC magnetron sputtering either on unbuffered SiO₂(100) substrates or on the substrates capped by a 50 nm thick V buffer layer. The effects of the vanadium buffer layer and of the film thickness are revealed by FMR studies of the Co₂Cr_{0.6}Fe_{0.4}Al samples. Well-resolved multiple spin-wave modes are observed in the unbuffered Co₂Cr_{0.6}Fe_{0.4}Al sample with a thickness of 100 nm and the exchange stiffness constant has been estimated. Thin films of Co₂MnSi (4-100 nm) have been grown by DC sputtering on silicon substrates on top of a 42 nm thick V seed layer and capped either by Al₂O₃ or by Co and V layers. A set of the 80 nm thick films has been annealed at different temperatures in the range of 425-550°C. FMR studies of the Co₂MnSi samples shows that at the fixed annealing temperature (450°C) the highest magnetization is observed in the sample with a thickness of 61 nm, while the thicker samples (100 nm) reveal not only a lower magnetization but greater magnetic inhomogeneity as well. An annealing treatment at $T \geq 450^\circ\text{C}$ is essential to obtain higher magnetization as well as uniform magnetic properties in the Co₂MnSi films. Weak SWR modes have also been observed in the thick Heusler films. © 2006 WILEY-VCH Verlag GmbH & Co. KGaA.

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